NEET SS ANAESTHESIA
PAEDIATRIC & NEONATAL ANAESTHESIA

CONTENT

PAEDIATRIC AIRWAY MANAGEMENT

Anatomy

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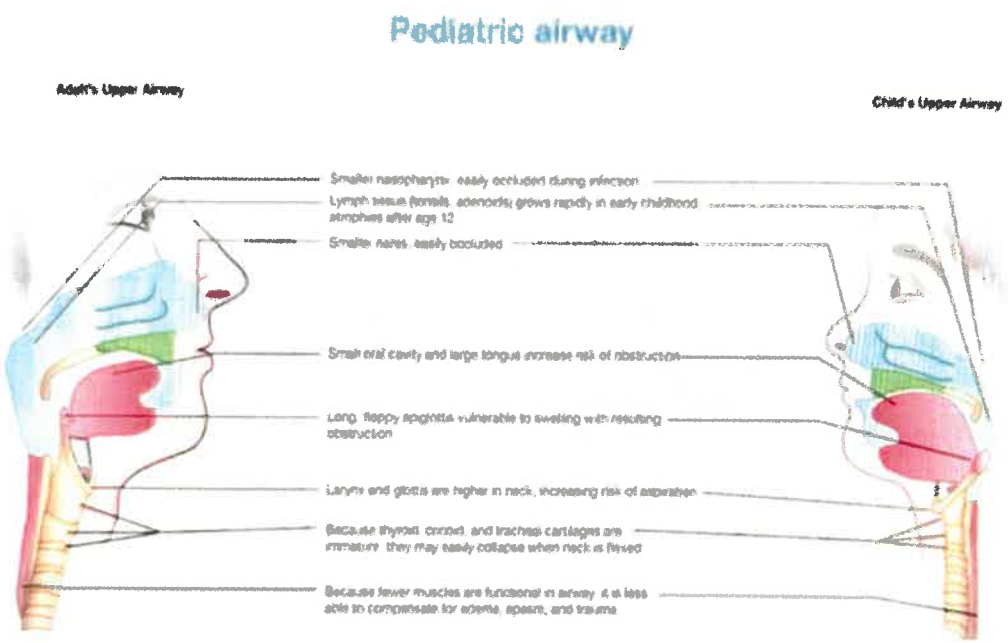
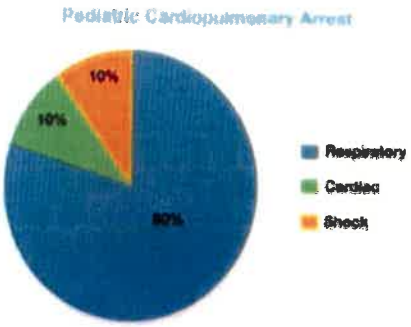
The paediatric airway :



Note : most pediatric arrests are of respiratory etiology.

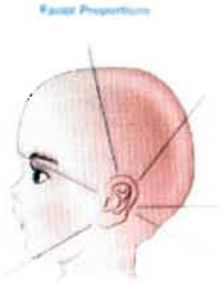


Age group :

- Neonates : 1st 28 days.
- Infants : 1st year.
- Child : upto 8 years, different anatomy.

The differences are most pronounced at birth and most unfamiliar under 1 year of age.

Craniofacial anatomy :



Paediatric age group :

- Airway is crowded in initial stages of life.
- Children are not small adults.
- Head is larger with a relatively shorter neck .
- Flexed neck results in airway obstruction.
- Laryngoscopy is difficult as the OPT (Oro Pharyngeaal Tracheal) axis doesn't align.
- Softer tissue and absence of bony prominence makes standard mask holding techniques ineffective.

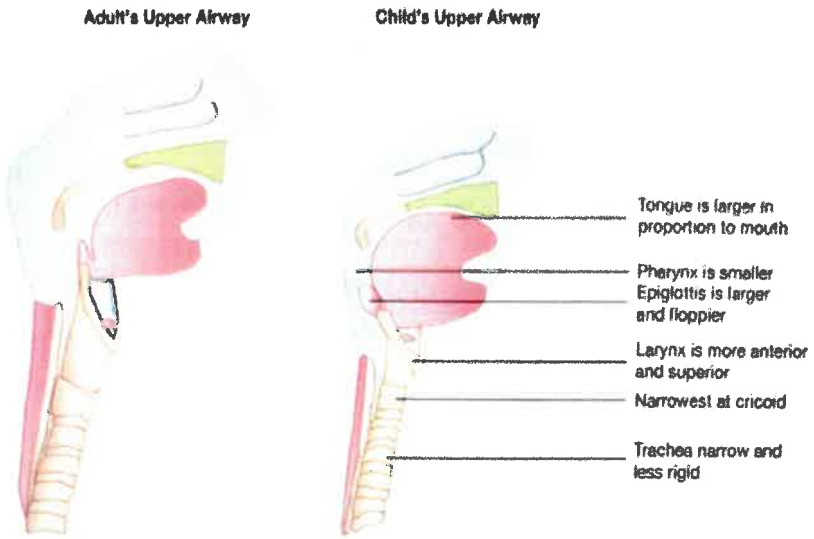
Anatomy of nose :

- Infant : Blockage of nose → Respiratory distress.
- They are obligate nasal breathers until 5 months.
- Nose/pharynx is responsible for 50% of total airway resistance :
  - Kid's noses are shorter, flatter, with small circular nares.
  - 20 mm in diameter.

Anatomy of tongue :

- The tongue is proportionally large & occupies most of the oral cavity.
- The mandibular space is small.
- Adenoids and tonsils are prominent.
- Loss of tone can be reduced by : Sleep, sedatives, hypnotics & anaethetics cause obstruction (Tone is normally low in children).
  - Difficulty with mask ventilation & obstruction.
  - Frequent cause of upper airway obstruction.
  - This phenomenon is called the tongue fall.
- It is the step 1 of differential diagnosis of children.

Cross section of both the adult and paediatric larynx



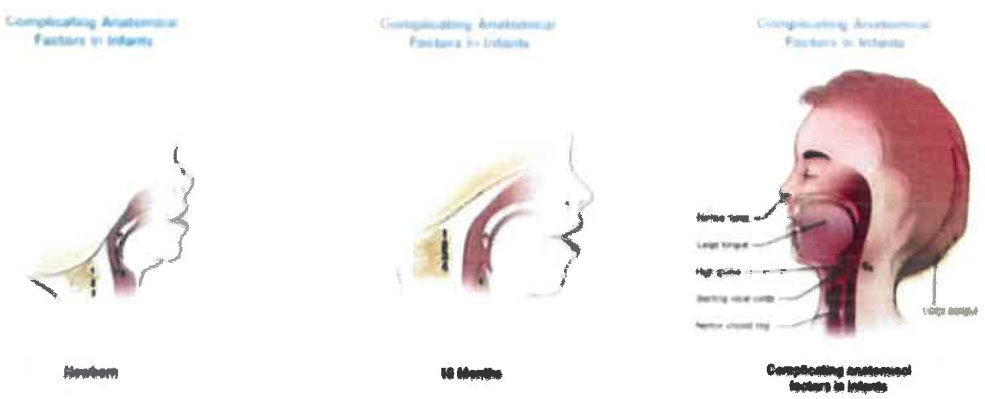
Anatomy of larynx :

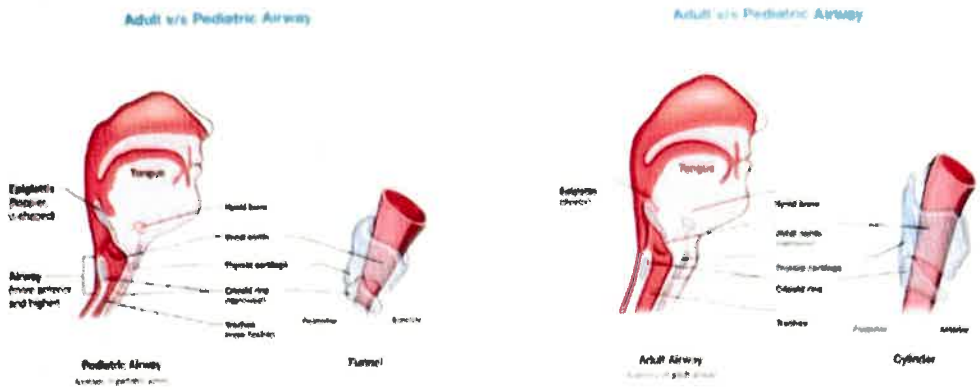
Larynx anatomical considerations :

- The infants larynx is higher (Rostral) in the neck & more anterior.
  - Neonates : C1 (VC : C4).
  - Six months : C3 (VC : C5).
  - Adults : C4-6 (VC : C6).
- Angled vocal chords (Posterior end is higher than the anterior end) affects the tube placement.
- With suboptimal views this can result in trauma.
- Can collide with the anterior commissure of the vocal chords and cause edema.

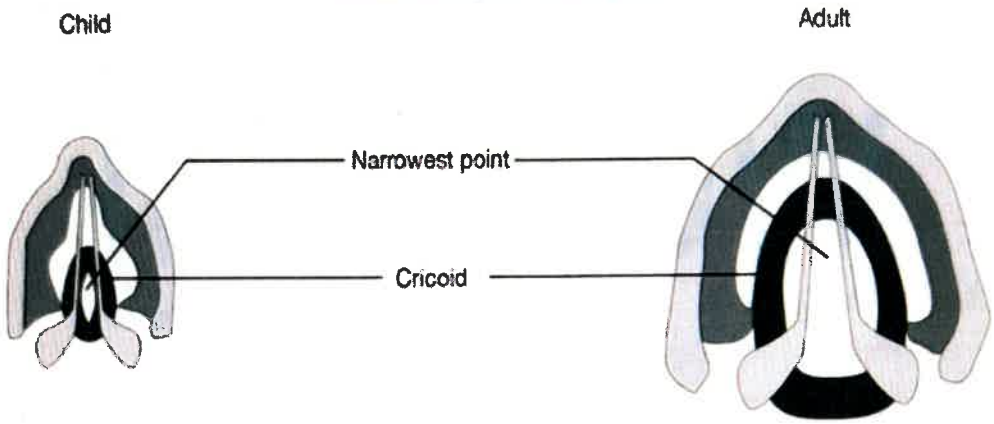
Note :

Narrowest point of larynx = Cricoid cartilage in the child till 8 years (In adults it is the vocal cords).



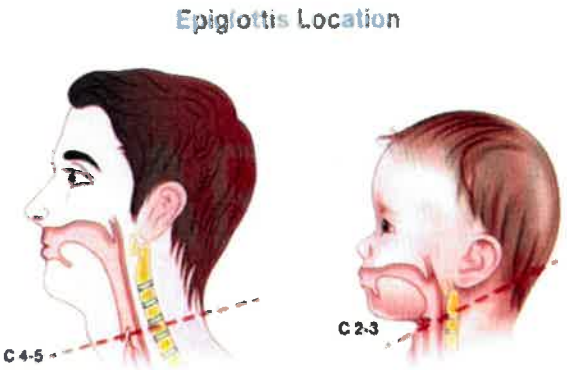


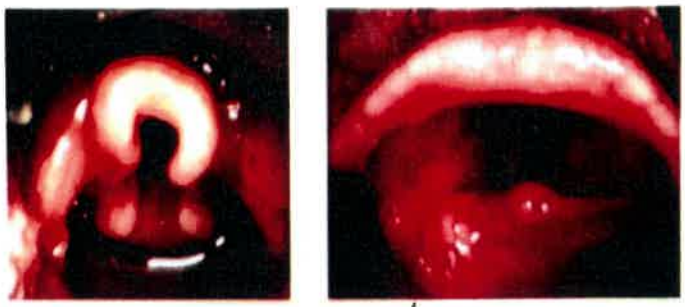
Anatomy of Larynx



Epiglottis Location :

- Adult : C4-5.
- Child : C2-3.
- Relatively large size in children.
- Floppy & not much cartilage.
- Neonate : U shaped epiglottis.
- Child : Omega shaped epiglottis.
- Choice of blade : Straight blade over curved as to include epiglottis.

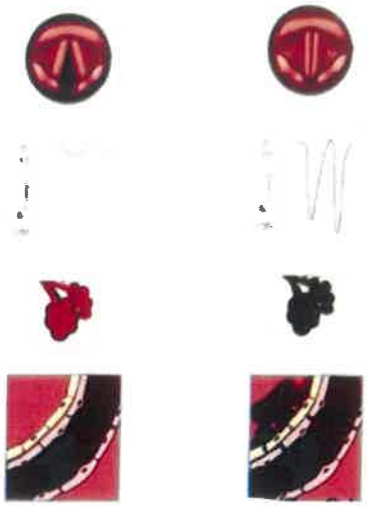




Adult v/s paediatric epiglottis

Airway anatomy :

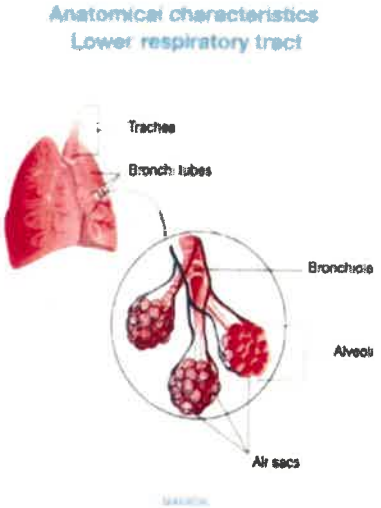
- Hyoid bone is the 1st airway structure to ossify.
- The cartilaginous portions of the airway are soft and compliant.
- Laryngospasm is more common.
- Negative pressure results in dynamic obstruction leading to negative pressure pulmonary oedema.
- PEEP is so effective.



Airway pattern

Anatomy of lower respiratory tract (LRT) :

- The trachea is short.
- Tracheal and bronchial passes in children is relatively small, soft cartilage, the lack of elastic tissue.
- Right bronchus : Is more straight, like a direct extension of the trachea (Causing the right lung atelectasis or emphysema).
- Left bronchus : Is the separation from the trachea.
- The bronchus is divided into inter-lobe bronchus, segmental bronchus & bronchioles.

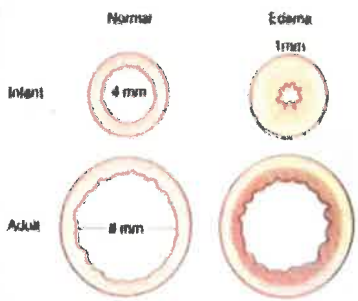


- LRT : Vulnerable, easy to cause airway narrowing and obstruction.
- Bronchioles : No cartilage, smooth muscle imperfect development, mucosa rich in blood vessels, mucous glands hypoplasia, lack of secretion of mucus, poor mucociliary movement.

Physiology :

Effect of edema :

- Poiseuelle's law $R = 8\eta l/\pi r^4$
  - R = Resistance.
  - η = Viscosity.
  - l = Length.
  - r = Radius.



Effect of edema

- Internal diameter of trachea in newborns = 1/3 of adult ($8^1 \times R$).
- Radius is the most important determinant of resistance of the airway.
- Small changes in airway diameter in infants/children due to edema/secretions creates a greater effect on resistance.
- Narrowest point = Cricoid cartilage in the child.
- 4^4 = 256 times more.
- Resistance rapidly increases as diameter decreases.
- If radius is halved, resistance increases 16x.

Management

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Basic airway management :

- Goal of airway management is to anticipate and recognize respiratory problems and to support or replace those that are compromised or lost (Pediatric Advance Life Support manual).
- An individual must be able to support three specific functions :
  - Protect their airway.
  - Adequately ventilate.
  - Adequately oxygenate.
- Failure to perform one will result in respiratory failure.
- There are many simple, non-invasive techniques to support respiration prior to endotracheal intubation :
  - Mnemonic : SOAPPME.
  - Suctioning.
  - Application of oxygen.
  - Adjuncts :
    i. Nasopharyngeal airway.
    ii. Oropharyngeal airway.
- Positioning of the airway.
- Application of positive pressure.
- Assistance of mechanical ventilation with BVM.

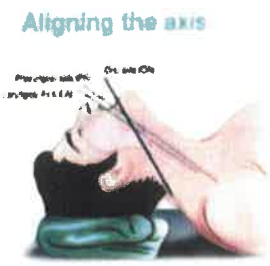
Positioning :

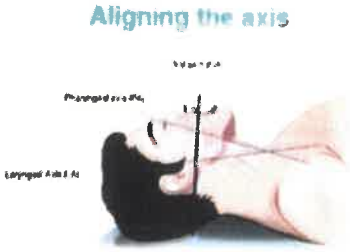
- Use of the head tilt, chin lift and jaw thrust can help restore flow through an obstructed upper airway by separating the tongue from posterior pharyngeal structures.

Aligning the axis :

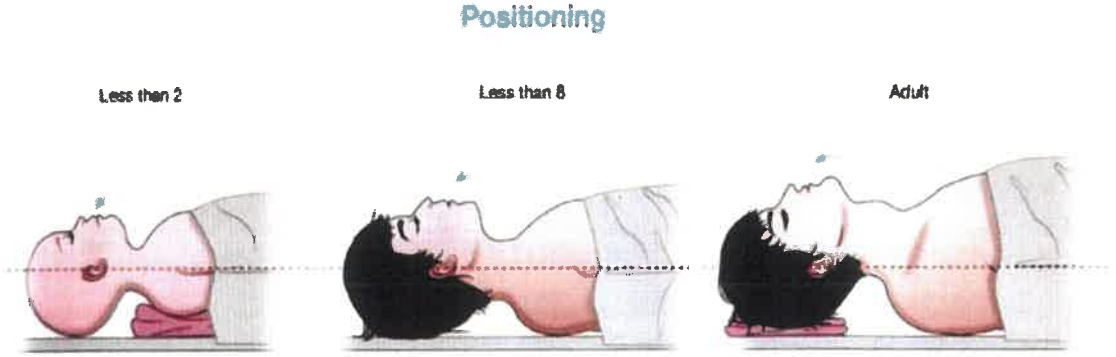
The goal is to line up three divergent axes :

- Oral.
- Pharyngeal.
- Tracheal.





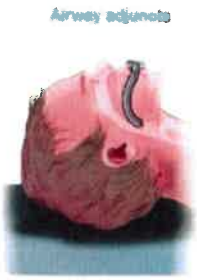
Positioning :



Airway adjuncts :

i. Oropharyngeal airways :

- Angle of mouth to angle of mandible.
- Facilitates relief of upper airway obstruction due to a large tongue.
- Allows oropharyngeal suctioning.
- Prevents compression of a child's endotracheal tube due to biting.



ii. Nasopharyngeal airways :

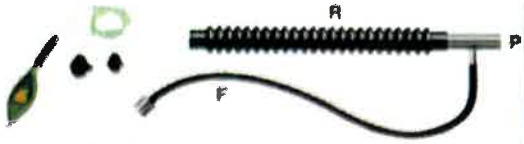
- Nostril to tragus.
- Tolerated while awake.
- Supplementary oxygen insufflation.
- A regular ETT can be cut and used as a nasal airway.

Bag mask ventilation :

- The most important skill.
- Masks should fit easily over the nose & mouth with no pressure on the eyes.
- The base of the mask rests on the chin.
- $ETCO_2$ monitors helps determine if effective.
- Multiple intubation attempts kill kids.

Bag-Jackson Rees circuit :

- Has no valves.
- minimal dead space.
- Light weight.



Bag-Jackson Rees circuit

Closed circuit

Bag and mask ventilation :

- Clear, plastic mask with inflatable rim.
- Provides atraumatic seal.
- Proper area for mask application-bridge of nose extend to chin.
- Maintain airway pressures <20 cm H2O (Barotrauma at the level of alveoli).

methods to hold and establish chin lift :

- Place fingers on the mandible to avoid compressing pharyngeal space.
- Hand on ventilating bag at all times to monitor the effectiveness of spontaneous breaths.
- Continuous positive pressure when needed to maintain airway patency.

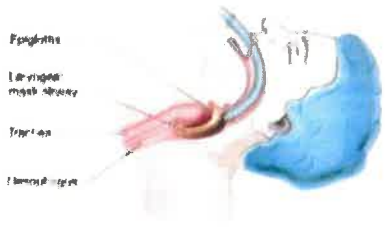
Bag and mask ventilation

Laryngeal mask airways :

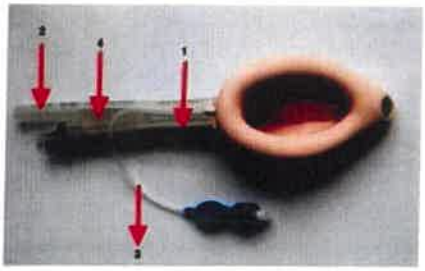
Between sizes :

- Use higher number & less air.
- Better anatomic fit.

Weight	Size	ml
0-5 kg	1	4
5-10 kg	1.5	7
10-20 kg	2	10
20-30 kg	2.5	14
30-50 kg	3	20
> 50 kg	4	30



Proximal portion of LMA rests upon the aryglottis and the distal end extends till the upper end of the esophagus

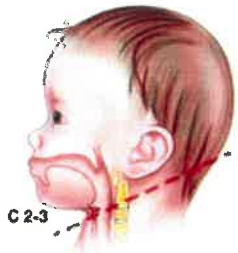


Laryngeal mask airway

Clinical pearl :

Intubation :

- Larynx cephalad and anterior in children.
- Practitioner may need to be lower than patient and look up.



Laryngoscope blades :

Age	miller	mac
Preterm	00	-
Neonate	0	-
Infant	1	1
2 yrs	2	1

Macintosh Miller

Intubation technique :

- Better in younger children with a floppy epiglottis.
- Straight Laryngoscope Blade : To pick up the epiglottis.
- Better in older children who have a less floppy epiglottis.
- Curved laryngoscope blade is placed in the vallecula.

Cole's formula :

Children > 2 years :

- ETT size : Age/4 + 4.
- ETT depth (Lip) : Age/2 + 12

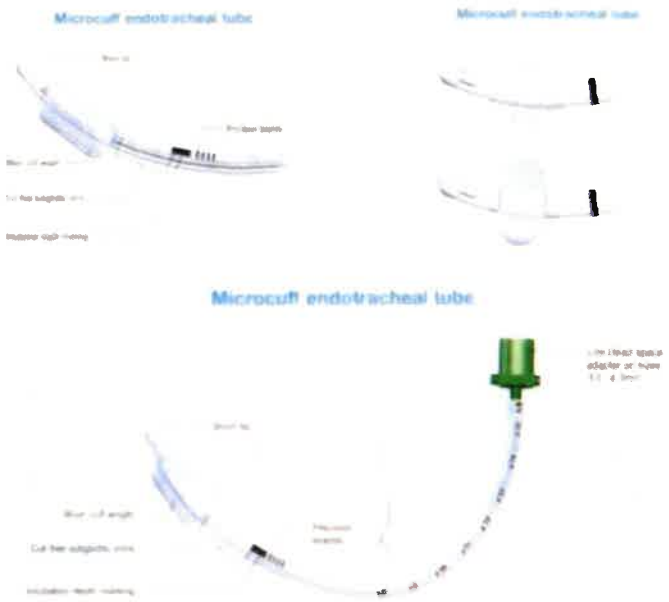
Age	Kg	ETT	Length (lip)
Newborn	3.5	3.0-3.5	9
3 mos	6.0	3.5	10
1 yr	10	4.0	12
2 yrs	12	4.5	12

Types of tube :

- Uncuffed endotracheal tube.
- Cuffed endotracheal tube.
- Microcuffed endotracheal tube.

Micro-cuff tube :

- 10 microns thin.
- 10 cm h2o pressure.
- Elliptical paediatric airway seal with minimum pressure.



Preparation for endotracheal intubation :

- Needed personnel
- Monitoring.
- Endotracheal tubes, laryngoscope blades : Variety of sizes.
- Adjuncts (Stylets, oral airway, securing mechanism).
- Suctioning equipment : Size of suction catheter is 6-10 Fr.
- JR circuit attached to universal gas outlet at flow greater than 6 L/min.
- IV access.
- Medications drugs.
- Throatpack.

Confirm placement :

Look :

- Colour of patient.
- Mist in ET tube.

- Equal chest rise.

Listen :

- Remember that infants can easily transmit breath sounds to the stomach.
- There's nothing better than watching the ETT go through the cords.

Capnography : $ETCO_2$ trace (GOLD standard).

PAEDIATRIC RESPIRATORY SYSTEM

Physiologic considerations

00:01:48

Growth of the lungs :

First trimester :

- 5 weeks : A lung bud appear → Splits into left and right.
- 12 weeks : Organogenesis → Lung buds divide → Over and over again → Branch-like pattern.

Second trimester :

- Main airways are developed.
- Air sacs and blood vessels start to develop.

Third trimester (After 28 weeks) :

Preparing lung for breathing : Basement membrane becomes progressively thinner → Blood vessels start to form on the other side → O_2 transfer into the blood vessels through the membrane → Type 2 pneumocytes secrete surfactant → Surfactant coat → Reduces the surface tension.

Development of the surfactant layer.

Newborn :

- Fluid in their lungs → First breath after birth → Negative pressure expands the lung with air entering in it → Collapsed alveoli becomes the normal alveoli → Blood vessels open due to hypoxic pulmonary constriction → Decreased pulmonary vascular pressure.
- 15% alveoli develop in the birth.

0-6 months :

- Sharp increase in the number of air sacs in their lungs.

3 years :

- Mini adult lung develpos.
- Then increases as per height.

Cilia, alveoli and surfactants :

- In infants cilia are poorly developed → Decreased sweeping action of the cilia → Retention of secretions → High risk of laryngospasm.
- Alveoli are small in volume → ↑surface tension and ↑inflation pressure.
- Low surfactant.
- Less no of type 2 pneumocytes.

Cilia

Diaphragm & intercostal muscles :

Type I fibers (marathoners) :

- Slow twitch, high oxidative.
- Fatigue resistant.
- Used in long run.

Type II fibers (Sprinters) :

- Seen in higher number in infants and children.
- Fast twitch, low oxidative.
- Fatigue prone.
- Less energy efficient.
- Cause shallow, rapid and tired breathing.

Percentage of type I fibers :

Age	Diaphragm (%)	Intercostal (%)
Preterm	10	20
Term	25	45
1 year old	55	65
Adult	55	65

Clinical significance :

- Early fatigue with ↑ work of breathing → Intubation & mechanical ventilation.

Pulmonary compliance :

Lung compliance :

- Decreased elastin.
- Static elastic recoil.

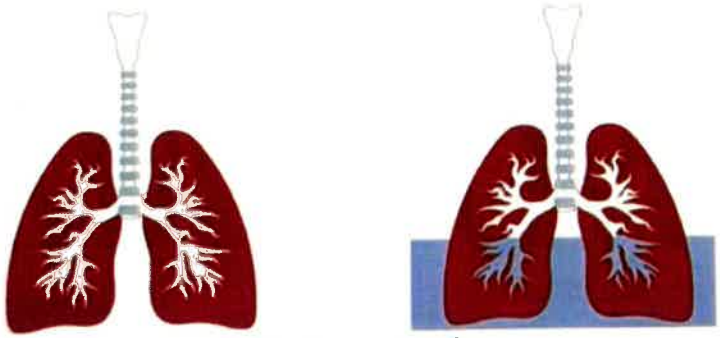
} Smaller volume of the lungs.

Chest wall compliance :

- Cartilaginous ribs.
- Less tone of muscles.
- Chest wall becomes extra compliant → Resting state becomes small → Negative pressure decreases → Lower expansion.

Ventilation and perfusion :

- Ventilation is distributed more to the upper lung → more number of smaller, collapsed alveoli in the base of the lungs.
- But the perfusion is equally distributed since children are short, lie flat and due to higher hydrostatic pressure.
- So the dependent areas with the collapsed alveoli still have the higher perfusion → Leading to shunt → Increased incidence of hypoxia and desaturation.



Ventilation and perfusion.

Airway resistance :

- Work of breathing is same as of adults is measured on 'ml/kg' basis.
- Since children are smaller, they have higher O_2 consumption compared to their BMR.
- Nose :
  - Adult : 60% (Obligate nasal breathers).
  - Infant : 25%.
- Bronchi and small airways :
  - Collapse inwards → Small diameter.
  - Greater compliance of supporting structures.
- Chest wall :
  - Increased compliance → Collapse inwards.
- All the above features lead to functional airway closure during breathing → Alveoli completely collapse and expand → High inspiratory pressure → Increased risk of barotrauma.

Exhalation :

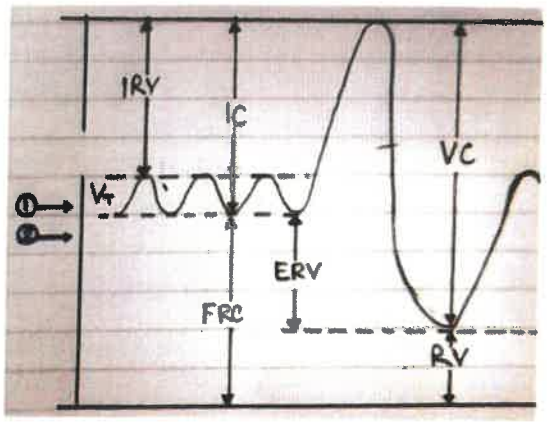
Dynamic FRC (Residual volume + Expiratory reserve volume) :

mechanisms to maintain higher FRC :

- Incomplete exhalation due to rapid respiratory rate → ↑residual volume → ↑ FRC.
- Laryngeal "braking" :
  - Adductor muscles contract creating PEEP.
  - Contracting muscles cause the outlet to become smaller → Obstruction to normal exhalation → ↑ residual volume.
- ↑ Intercostal muscle tone → ↑negative pressure → ↑inflation presure → ↑volume → ↑FRC.

Lung volumes (ml/kg) :

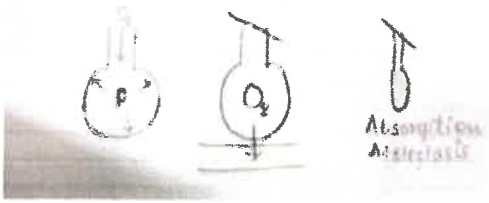
- In children tidal volume (V_T) is 6 ml/kg (Same as adult).
- The lungs occupy a higher proportion of the body surface area.
- Hence the lungs are proportionately less expanded and more collapsed.



Spirometry comparing the closing volume of children ① and adult (a).

Closing volume :

- Volume at which small airways begin to close.
- If there is any obstruction to the inflow of O_a → As the blood flows, there is absorption of O_a molecules → Absorption atelectasis → Collapse of alveoli → Pulomary edema.



Closing volume.

Clinical significance :

- All mechanisms for maintaining FRC are lost under anesthesia like :
  - Intercostal muscle tone disappears.
  - Adductor brachi tone disappears.
  - Decreased respiratory rate (RR).

  This leads to ↓ FRC.
- ↓ FRC → Airway closure → Atelectasis → V/Q mismatch → Hypoxemia.

management options :

- Earlier intubation and ventilation.
- Application of PEEP.
- Reverse muscle relaxation.

Impact of specific anesthetic agents :

- Desflurane may lead to bronchoconstriction in children with hyperreactive airways.
- Propofol depresses respiratory center, decreased CO_2 drive.
- Midazolam :
  - As a premedication in preschool children may cause a small reduction of FRC and respiratory compliance.
  - Comparatively safer.
  - It can increase upper airway resistance, potentially compromising breathing.
- Ketamine has variable effects on FRC and ventilation homogeneity, with the impact on breathing frequency ranging from apnea to increased RR.
- Opioids may activate chest and abdominal wall muscles, potentially causing chest wall rigidity in adults, and difficult mask ventilation in some children.

Alveolar ventilation :

↑ O_2 consumption in growing tissue and high BMR :

- 3x adult values in preterm.
- 2x adult values in infant (6-7mL/kg/min).
- Clinical significance : Rapid oxygen desaturation during apnea.

↑ alveolar ventilation :

- 2-3x adult values.
- Increased RR.
- Clinical significance : Greater speed of mask induction and emergence.

Early desaturation in paediatrics age group :

- Work of breathing : 15% of total oxygen consumption.
- Fetal Hb is ↑ of O_2 availability is poor.
- Limited respiratory reserve.
- No 'bucket handle' :
  - In children the ribs are more horizontal compared to that of adults which resembleas a bucket handle.